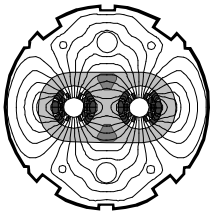

the **Large Hadron Collider** project

LHC Project Document No.
LHC-DFBX-ES-230.00 rev 1.1

CERN Div./Group or Supplier/Contractor Document No.
LH 20 00

EDMS Document No.
313360

Date: 2001-07-11

Interface Specification

DFBX - LBX

Abstract

This specification establishes the detailed interface requirements between the DFBX and the superconducting D1. This specification applies to the DFBX at IR2 (left and right), and IR8 (left and right).

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History of Changes

Rev. No.	*Date*	*Pages*	*Description of Changes*
1.0	5 May 2001	All	Initial Submission
1.1	7 June 2001	4	Added drawing reference for vent transfer bellows.
		7-8	Corrected figures 5.2-1 and 5.2-2; Z-dimension of Ex to 252.5.
		9-10	Tables 5.3-1,2: Changed Y-location of XB and eliminated note j.
		8-10, 12,14	Deleted "cryogenic" from various sections and tables.
		13	Table 5.8-2: Filled in XB bellows data from drawing; deleted note c.
		13	Table 5.8-2: Added note b and corrected beam tube bellows OD.
		13	Section 5.8: Noted bellows liners and shrouds for buckling prevention.
		14	Deleted figure 5.9.1-1; added CERN responsibility for flange design.
		14	Changed flange to LHC drawing number and added reference [f].
		14-18	Corrected figure numbers.
		16	Updated figure 5.9.3-1 with data from XB bellows.
		18	Added section 5.9.7 and figures 5.9.7-1,2.
		21	Clarified basis of O-ring design, section 5.11.1.
		23	Added drawing reference [o].
1.1	11 July 2001	all	First released version

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1. INTRODUCTION

This specification establishes the detailed mechanical and electrical interface requirements between the DFBX and the superconducting D1. This specification applies to DFBXC (IP2 Left), DFBXD (IP2 Right), DFBXG (IP8 Left), and DFBXH (IP8 Right). The interfaces defined herein must be consistent with the applicable interfaces in the D1 Interface Specification [1]. Interface requirements between the DFBX and the warm D1 are covered in the DFBX to beam tube interface specification [2].

2. INTERCONNECT RESPONSIBILITIES

Table 2-1. Interconnect components and institutional responsibilities.

Component	**Connecting Components LBX to DFBX**	**Drawing Number**	**Responsible Laboratory**
DFBX Assembly	N/A	TBD	LBNL
DFBX thermal shield bridge	LBX to DFBX	TBD	LBNL
Instrumentation line flex hose	i to MBX2	TBD	LBNL
Shield line bellows	e1 to Ex, e2 to E2	LHCLQXI_0010 [a]	LBNL
Flanges for shield lines	e1 to Ex, e2 to E2	LHCLQXI_0007 [b]	LBNL
Cool down bellows	c to LD1	LHCLQXI_0001 [c]	LBNL
Cool down line flange	c to LD1	LHCLQXI_0006 [d]	LBNL
Beam tube bellows	V to V	TBD	CERN
Beam screen supply flex hose	c' to CC'2	TBD	LBNL
Heat exchanger inner tube flex hose	cy, cy_t to CY2	TBD	LBNL
Flange weld rings	N/A	TBD	LBNL
LBX Assembly	N/A	TBD	BNL
Electrical soldering equipment	N/A	N/A	CERN
LBX vacuum bellows closure and flange	LBX to DFBX	TBD	BNL
Vent transfer line bellows	xb_t, xb to XB	LHCLBX_XXXX [o]	BNL
Cold mass bellows	m/c to MBX1	LHCLBX_0003 [e]	BNL
Flange	m/c line	LHCMBX_0003 [f]	BNL
Flange	MBX1 line	TBD	LBNL
Flange	i line	LHCMBX_0004 [g]	BNL

3. CO-ORDINATE SYSTEM

The local coordinate systems used in this specification are given in the DFBX General Interfaces Specification [3], and shown in Appendix A.

The origins of the DFBX local coordinate systems with respect to the CERN global coordinates are listed in Table 3-1. These locations are derived from the referenced CERN drawings and the flange to flange separation between the DFBX and the LQX of 510 mm [4]. The LBX local coordinate system is given in [1]. The origin of the room temperature LBX local coordinate system is 2875.2 mm farther from the IP than the origin of the DFBX local coordinate system.

Table 3-1. Position of DFBX Local Coordinate Systems

Code	Distance (mm) from IP	CERN Dwg. No.	Dwg. Ref. List
DFBXC	55052 Left of IP2	LHCLSX_0003D	[h]
DFBXD	55052 Right of IP2	LHCLSX_0004D	[i]
DFBXG	55052 Left of IP8	LHCLSX_0015D	[j]
DFBXH	55052 Right of IP8	LHCLSX_0016D	[k]

4. CRYOGENIC FLOW SCHEMATICS

The cryogenic flow schematics for the D1 magnets are shown on drawing LHCDFBX_0001 [l]. This drawing shows the connection of all inner triplet superconducting magnets to the CERN cryogenic distribution line for all eight DFBX's.

The cryogenic piping connections between the DFBX and LBX allow for:

- Thermal shield supply and return connections,
- D1 cooldown and initial filling from the low point,
- 1.9K supply to the high end of the magnet heat exchanger,
- 1.9K return from the low end of the magnet heat exchanger, and
- Quench venting from both ends of the D1 magnet cold mass.

The piping is consistent with the D1 Cooling Specification [5].

5. MECHANICAL INTERFACES

5.1 EQUIPMENT CODES

Because each of the eight DFBX may have a unique design, the following equipment codes have been adopted facilitating a direct application of the LHC documentation system. In Table 5.1-1, "IRnR" signifies the right side of the Interaction Point n, and IRnL signifies the left side of Interaction Point n.

Table 5.1-1. Individual DFBX Equipment Codes

Location	IR2L	IR2R	IR8L	IR8R
Code	DFBXC	DFBXD	DFBXG	DFBXH

5.2 DRAWINGS SHOWING TRANSVERSE DFBX PIPING LOCATIONS

The transverse locations and other features of the mechanical components of the DFBX-LBX interface at room temperature are defined in the drawings listed in Table 5.2-1. The features shown in these drawings are a planar section, taken at the plane of the vacuum vessel as seen from D1. Figures 5.2-1 and 2 show typical planar section views.

Table 5.2-1 Drawings showing DFBX Transverse Piping Dimensions

Location	LBNL Drawing No.	CERN No.	Drawing List
IR2L & IR8L	24C3236	LHCDFBX_0010	[m]
IR2R & IR8R	24C3246	LHCDFBX_0011	[n]

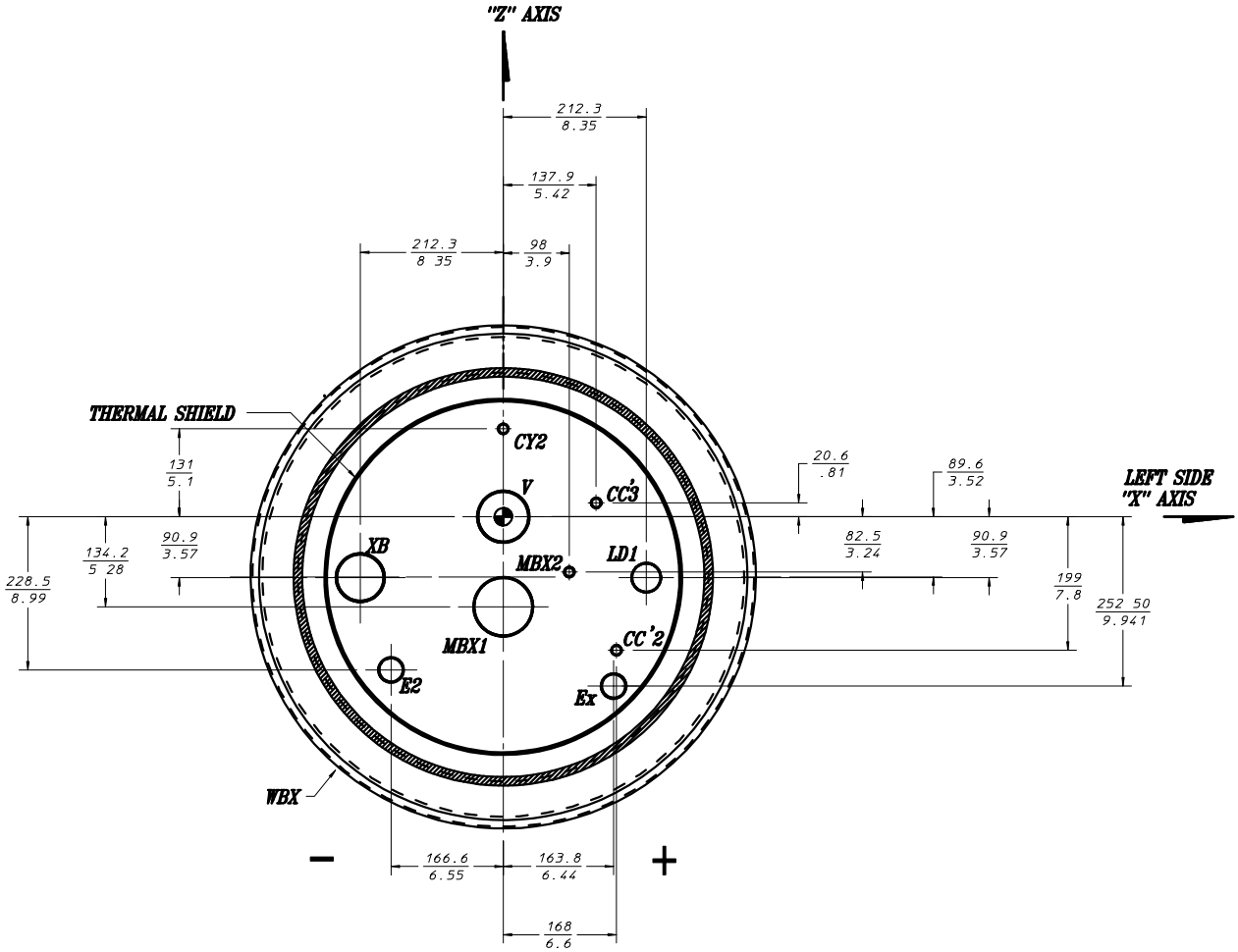


Figure 5.2-1. Typical left side DFBX transverse planar section at the DFBX exit flange as seen from D1. (Dimensions are mm/in.)

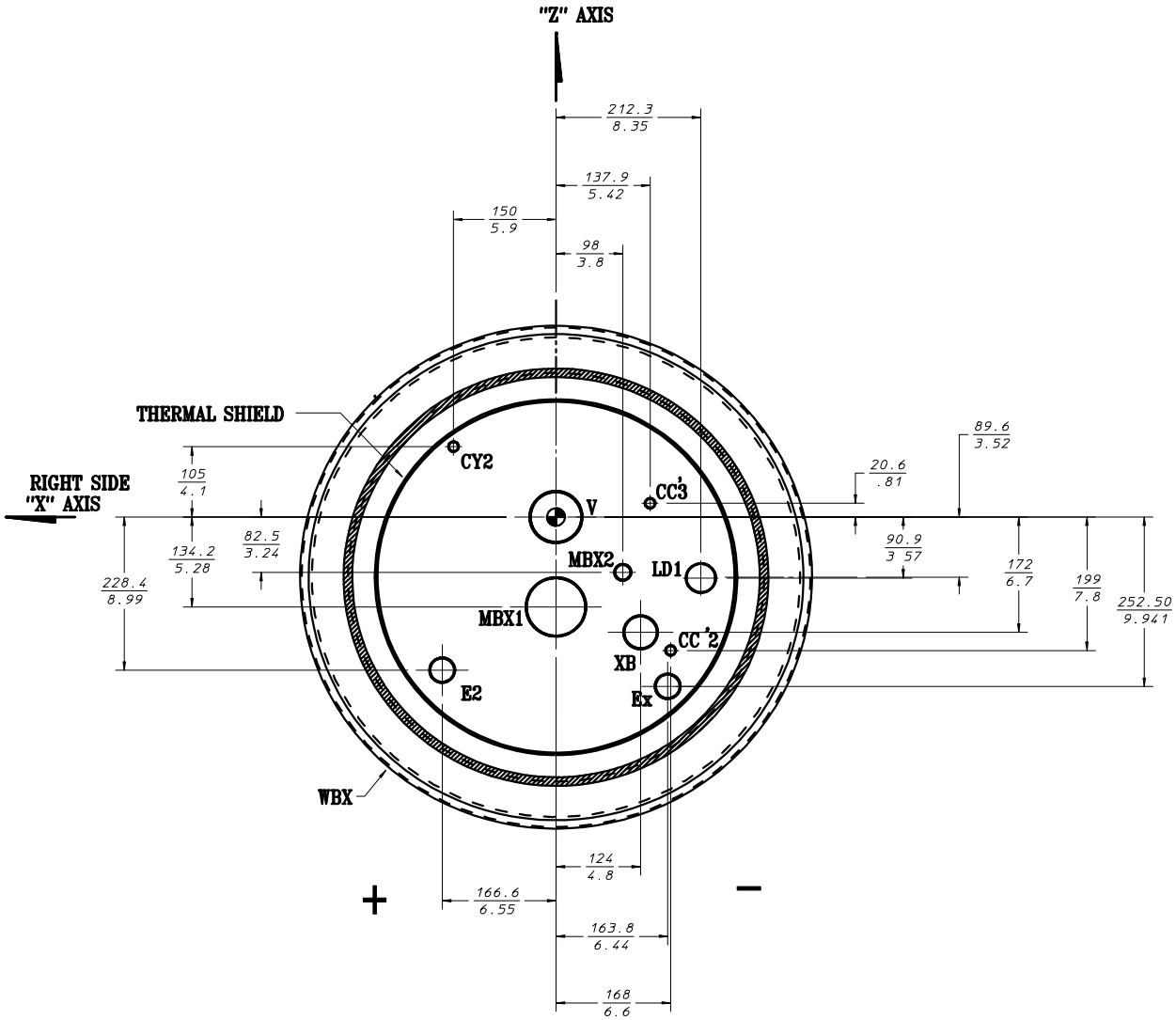
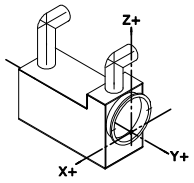


Figure 5.2-2. Typical right side DFBX transverse planar section at the DFBX exit flange as seen from D1. (Dimensions are mm/in.)

5.3 PIPING IDENTIFICATION AND WARM COORDINATES

Table 5.3-1 lists the pipes in the left-side DFBX (DFBXC and DFBXG) and the designations of the pipes in the LBX to which they are each connected. The (x,z) co-ordinates shown are those of the pipes in the DFBX at room temperature.

Table 5.3-2 lists the pipes in the right-side DFBX (DFBXD and DFBXH) and the designations of the pipes in the LBX to which they are connected. The (x,z) co-ordinates shown are those of the pipes in the DFBX at room temperature.



(DFBX reference coordinate system.)

Table 5.3-1 DFBX Left Side Piping Connections

Pipe Designation		Pipe OD/ID	Pipe Co-ordinates at 300 K		
LBX[f]	**DFBX[e]**	**mm**	**X, mm ±2**	**Z, mm ±2**	**Y[g], mm ±2**
V	V	78/74	0	0	-109.5
c[h]	LD1	44.4/41.9	212.3	-90.9	-101.5
c′	CC'2 End transition[i]	15.9/13.4 12.7/10.2	168	-199	-377
Not Shown[a]	CC'3	15.9/13.4	137.9[b]	20.6[b]	-377
cy	CY2 End transition[i]	15.9/13.4 12.7/10.2	0	131	-377
cy_t	Not Req'd[c]	----	----	----	----
e1[h]	Ex	38.1/34.8	163.8	-252.2	-56.5
e2[h]	E2	38.1/34.8	-166.6	-228.5	-56.5
m/c	MBX1	88.9/85.6	0	-134.2	-58.0
i	MBX2 End transition[i]	12.7/9.4 37.6/34.3	98	-82.5	-367
W	WBX	750/597	0	-89.6	0
xb	Not Req'd[d]	----	----	----	----
xb_t	XB End transition[i]	73.0/68.8 50.8/47.5	-212.3	-90.9	-92

Notes:

a. Beam screen cooling return to be provided later by CERN. See LHC-DFBX_-ES-220 [2].

b. Beam screen cooling return location. See LHC-DFBX_-ES-220 [2].

c. DFBX 1.9K supply is connected to line cy for this side.

d. DFBX 1.9K return is connected to line xb_t for this side.

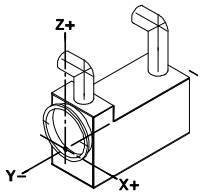
e. Labels per LHCDFBX_0001, cases DFBXC and DFBXG [l].

f. Labels from LBX Dipoles – D1 interface specification [1].

g. Dimension is from DFBX flange face on D1 side; add -2367.2 mm to reference Y from DFBX coordinate system origin.

h. BNL transition to LBNL pipe size.

i. LBNL transition to BNL pipe end.



(DFBX reference coordinate system.)

Table 5.3-2 DFBX Right Side Piping Connections

Pipe Designation		Pipe OD/ID	Pipe Co-ordinates at 300 K		
LBX[f]	**DFBX[e]**	**mm**	**X, mm ±2**	**Z, mm ±2**	**Y[g], mm ±2**
V	V	78/74	0	0	109.5
c[h]	LD1	44.4/41.9	-212.3	-90.9	101.5
c’	CC'2 End transition[i]	15.9/13.4 12.7/10.2	-168	-199	377
Not Shown[a]	CC'3	15.9/13.4	-137.9[b]	20.6[b]	377
cy	Not Req’d[c]	----	----	----	-----
cy_t	CY2 End transition[i]	15.9/13.4 12.7/10.2	150	105	377
e1[h]	Ex	38.1/22.1	-163.8	-252.2	56.5
e2[h]	E2	38.1/22.1	166.6	-228.4	56.5
m/c	MBX1	88.9/85.6	0	-134.2	58.0
i	MBX2 End transition[i]	12.7/9.4 37.6/34.3	-98	-82.5	367
W	WBX	750/597	0	-89.6	0
xb	XB	50.8/47.5	-124.	-172.	92
xb_t	Not Req’d[d]	----	----	----	-----

Notes:

a. Beam screen cooling return to be provided later by CERN. See LHC-DFBX_-ES-220 [2].

b. Beam screen cooling return location. See LHC-DFBX_-ES-220 [2].

c. DFBX 1.9K supply is connected to line cy_t for this side.

d. DFBX 1.9K return is connected to line xb for this side.

e. Labels from LHCDFBX_0001, cases DFBXD and DFBXH [l].

f. Labels from LBX Dipoles – D1 interface specification [1].

g. Dimension is from DFBX flange face on D1 side; add 2367.2 mm to reference Y from DFBX coordinate system origin.

h. BNL transition to LBNL pipe size.

i. LBNL transition to BNL pipe end.

5.4 TRANSVERSE LOCATIONS OF CRYOGENIC PIPING – LEFT SIDE

Table 5.4-1 lists the nominal transverse locations (in mm) at operating temperatures of the DFBX cryogenic piping and the locations of the corresponding pipes in the LBX.

Table 5.4-1 Transverse Cold Locations of Left-side DFBX[a] and LBX Piping

LBX Pipe Name[b]	DFBX Pipe Name	DFBX Cold Locations[c]		LBX Cold Locations[b]	
		X ±2	Z ±2	X	Z
c	LD1	211.8	-90.7	211.7 ± 3	-90.6 ± 3
c′	CC'2	167.6	-198.6	167.5 ± 2	-198.4 ± 2
---	CC'3	137.6	20.6	---	---
cy	CY2	0.0	130.7	0.0 ± 1	130.6 ± 1
e1	Ex	163.4	-251.6	163.1 ± 3	-251.6 ± 3
e2	E2	-166.2	-228.0	-166.1 ± 3	-227.7 ± 3
m/c	MBX1	0.0	-133.9	0.0 ± 1	-133.8 ± 1
i	MBX2	97.8	-82.3	97.7 ± 1	-82.3 ± 1
W	WBX	0.0	-89.4	0.0 ± 3	-87.7 ± 3
xb	XB	-211.8	-90.7	-211.7 ± 3	-90.6 ± 3

Notes:

a. DFBX Beam tube axis moves 0.2 mm in negative z-direction upon cool down, moving the DFBX coordinate system origin down 0.2 mm. There is no shift in the x-direction upon cool down.

b. From MBX – D1 Interface Specification, [1].

c. Cold coordinates above are relative to the DFBX cold beam tube.

5.5 TRANSVERSE BEAM TUBE OFFSET FOR LEFT-SIDE INSTALLATION

To ensure proper match of the beam tube and other cryogenic piping at operating temperature, the DFBX beam tube will be positioned 1.7 mm lower than the LBX beam tube at installation at room temperature.

5.6 TRANSVERSE LOCATIONS OF CRYOGENIC PIPING – RIGHT SIDE

Table 5.6-1 lists the nominal transverse locations (in mm) at operating temperatures of the DFBX cryogenic piping and the locations of the corresponding pipes in the LBX.

Table 5.6-1 Transverse Cold Locations of Right-side DFBX [a] and LBX Piping

LBX Pipe Name[b]	DFBX Pipe Name	DFBX Cold Locations[c]		LBX Cold Locations[b]	
		X ±2	Z ±2	X	Z
c	LD1	-211.8	-90.7	-211.7 ± 3	-90.6 ± 3
c′	CC'2	-167.6	-198.6	-167.5 ± 2	198.4 ± 2
---	CC'3	-137.6	20.6	---	---
cy_t	CY2	149.7	104.8	149.6 ± 2	104.7 ± 2
e1	Ex	-163.4	-251.6	-163.1 ± 3	-251.6 ± 3
e2	E2	166.2	-227.9	166.1 ± 3	-227.7 ± 3
m/c	MBX1	0.0	-133.9	0.0 ± 1	-133.8 ± 1
i	MBX2	-97.8	-82.3	-97.7 ± 1	-82.3 ± 1
W	WBX	0.0	-89.4	0.0 ± 3	-87.7 ± 3
xb	XB	-123.7	-171.6	-123.6 ± 2	-171.5 ± 2

Notes:

a. The DFBX beam tube moves 0.2 mm in negative z-direction upon cooldown, moving the DFBX coordinate system origin down 0.2 mm. There is no shift in the x-direction upon cooldown.

b. Taken from MBX – D1 Interface Specification, [1].

c. Cold co-ordinates above are relative to the DFBX cold beam tube.

5.7 TRANSVERSE BEAM TUBE OFFSET FOR RIGHT-SIDE INSTALLATION

To ensure proper match of the beam tube and other cryogenic piping at operating temperature, the DFBX beam tube will be positioned 1.7 mm lower than the LBX beam tube at installation at room temperature.

5.8 LONGITUDINAL MOVEMENT OF PIPING

The longitudinal interconnection regions between the LBX and DFBX are shown on CERN layout drawings of the Long Straight Sections [h-k]. The drawings also show a CERN-defined virtual interconnect plane.

Upon cooling to operational temperature, the piping connections between the LBX and DFBX will move apart because of thermal contraction. The amount of thermal contraction will be determined by the amount of temperature change, the thermal contraction coefficient, and the lengths of the pipes involved.

The expected thermal motion of the piping in the LBX-DFBX interface is given in table 5.8-1. In the table, the free lengths are measured from the virtual interconnect plane as defined by CERN [h-k]. Bellows are required to allow this motion, and the column "total change" is the required stroke that the bellows must provide. Lines without bellows have flexible hoses or expansion loops.

Table 5.8-1 Longitudinal Motion Upon Cooling To Operational Temperature

DFBX Pipe No.	Free Length on LBX Side (mm)	Change on LBX Side	Total Change	Change on DFBX Side	Free Length on DFBX Side (mm)
V	5373	16.1	20.3	4.2	1398
LD1	5373	16.1	17.9	1.8	584
CC'2	5373	16.1	17.9	1.8	584
CC'3	5373	16.1	20.3	4.2	1398
CY2	5373	16.1	17.9	1.8	584
Ex	5373	16.1	20.3	4.2	1398
E2	5373	16.1	17.9	1.8	584
MBX1	5373	16.1	20.3	4.2	1398
MBX2	5373	16.1	17.9	1.8	584
XB	5373	16.1	23.0	6.9	2284

Table 5.8-2 lists design parameters and geometry of the required bellows. The bellows were used to develop the layouts in Section 5.9. The end treatment of the bellows allows the assembly to be installed with an automatic, orbital welding machine when space permits. Bellows have liners or external shrouds to prevent buckling.

Table 5.8-2, LBX-DFBX Bellows Design Parameters

DFBX Pipe No.	ID (mm)	OD (mm)	Int.Des. Pres. (Bar)	End Tube Parameters ID x wall x length (mm)	Comp. Length[a] (mm)	Free Length[a] (mm)	Reqd Stroke (mm)	Ref. Dwg. List
V[b]	88.9	124	0	tbd	tbd	tbd	20.3	tbd
LD1	57.7	73.7	20	57.2 x 0.889 x 42.4	231.0	250.0	17.9	[c]
CC'2				Loop/ Flexible hose			17.9	tbd
CC'3				Loop/ Flexible hose			20.3	tbd
CY2				Loop/ Flexible hose			17.9	tbd
Ex	39.3	63.0	22	39.0 x 0.889 x 42.4	231.0	250.0	20.3	[a]
E2	39.3	63.0	22	39.0 x 0.889 x 42.4	231.0	250.0	17.9	[a]
MBX1	90.4	103.1	19	89.6 X 1.52 X 57.9	244.0	254.0	20.3	[e]
MBX2				Flexible Hose			17.9	tbd
XB	57.2	69.9	19	50.8 x 1.65 x 50.8	251.0	254.0	23.0	[o]

a. Overall length, including end tubes.

b. CERN bellows yet to be designed; minimum OD recommended by I. Collins.

5.9 PIPING CONNECTION DETAILS

5.9.1 BEAM TUBE CONNECTION

The D1 bore tube is to be fitted with CERN-supplied hardware that provides a beam screen with cooling. The end of the bore tube will be fitted with a provision for beam screen cooling connections and be terminated in a flange to allow the interconnecting bellows to be welded. The tube on the D1 side is 175 mm from the end volume. The flanged tube on the DFBX side will extend 109.5 mm past the DFBX vacuum flange. The DFBX bore tube will be fitted with a CERN-approved weld flange; flange dimensions will be determined once the interconnect design has been resolved by CERN. Table 5.8-2 gives the minimum OD for the beam tube bellows. The bellows for the beam tube connection will be provided by CERN. (See Table 2-1.) The sliding RF joint supplied by CERN will be located in the interconnect region between these pipes. After the sliding joint is installed, the CERN provided beam tube bellows is slid into position and is sealed by welding. Details of the beam tube connection are given in LHC-DFBX-ES-220 [2].

5.9.2 BUS DUCT CONNECTION

Figure 5.9.2-1 shows the layout of the interconnection between the m/c duct in D1 and the MBX1 duct in the DFBX. The bellows assembly is slid back on the D1 end while the electrical connections are made in the 206-mm-long open space. (The bus electrical connection details are given in Section 6.1 below). After the electrical connections are made, the bellows is slipped into place over weld flange on the m/c pipe. Flange LHCMBX_0003 [f] will be welded to the m/c tube stub on one end and the bellows on the other end. The opposite end of the bellows will be welded to the flange-ended MBX1 pipe.

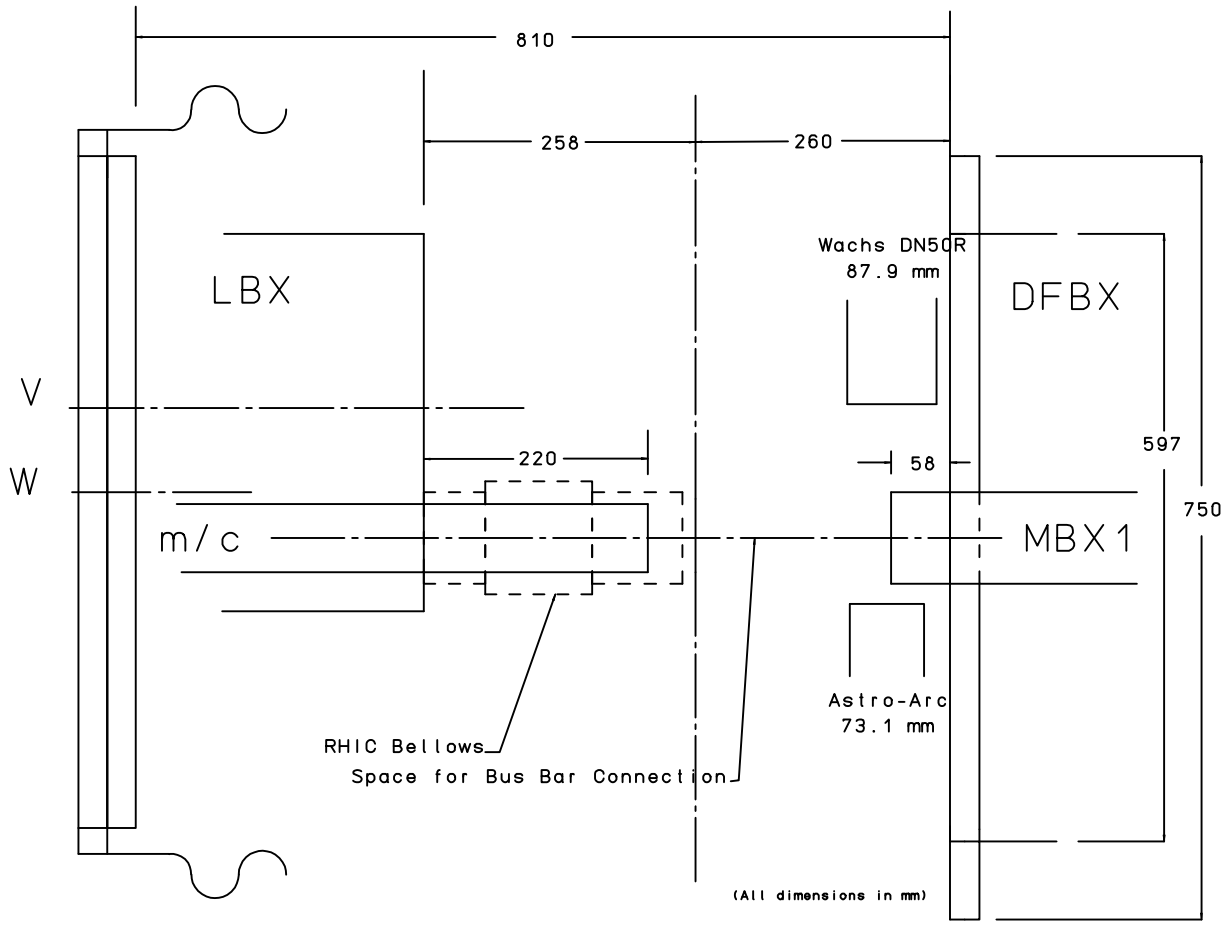


Figure 5.9.2-1 D1-DFBX Bus Duct Connection Layout

5.9.3 1.9K PUMPING LINE CONNECTION

Figure 5.9.3-1 shows the interconnection layout for the XB lines. We show both types of XB connections in the Figure. Even though the XB diameters on the left and right sides of the IP differ, a common bellows assembly will be used for both. A transition flange will be used for the smaller diameter tube connection.

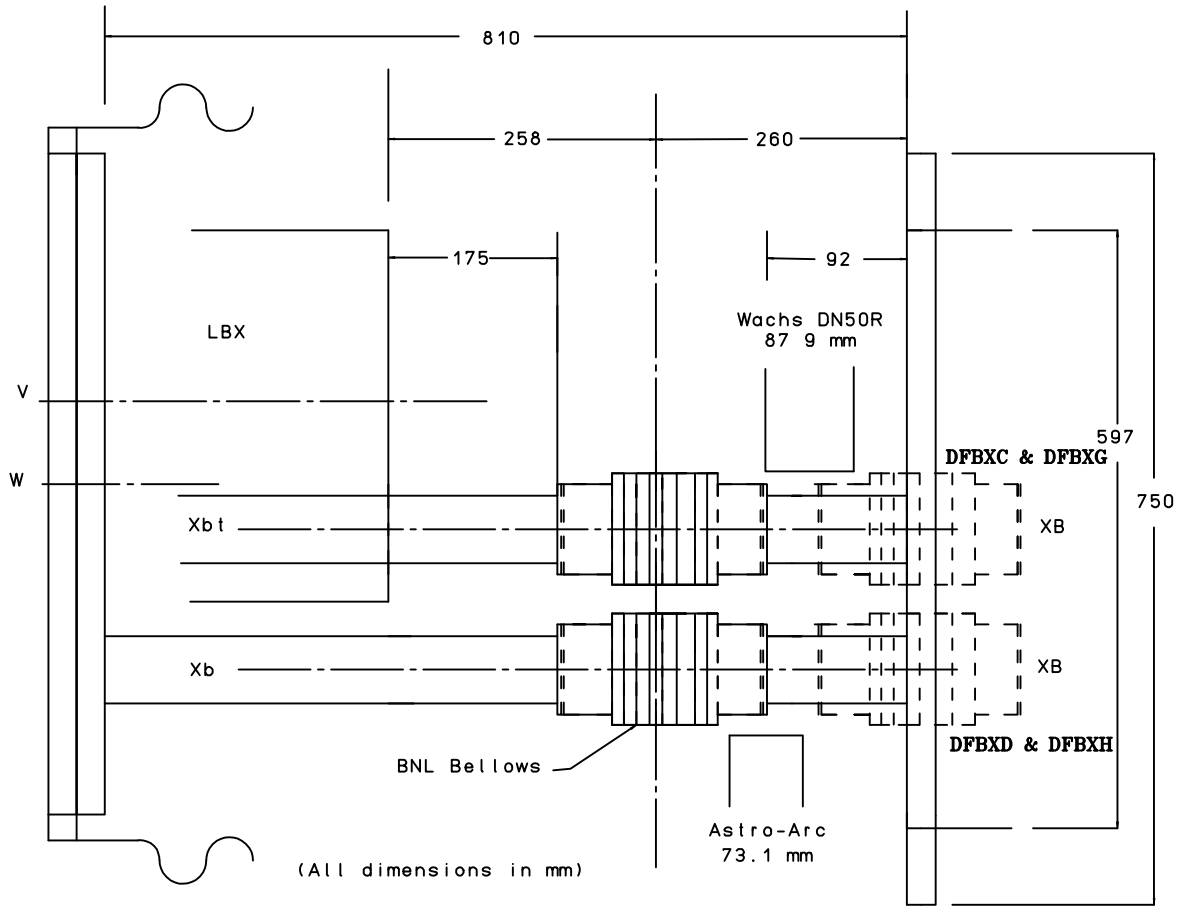


Figure 5.9.3-1 XB Pumping Line Interconnection Layout

5.9.4 COOLDOWN/VENT (LD1) PIPING CONNECTIONS

The interconnection between the c line in the LBX and LD1 in the DFBX is shown in Figure 5.9.4-1. The bellows assembly is stored on the DFBX piping while the DFBX is installed. The bellows assembly is slid into position and welded to the special flanges using the orbital welding machine. In case the joint needs to be cut apart, the CERN cutting machine (Wachs DN50R) is used as shown in the figure.

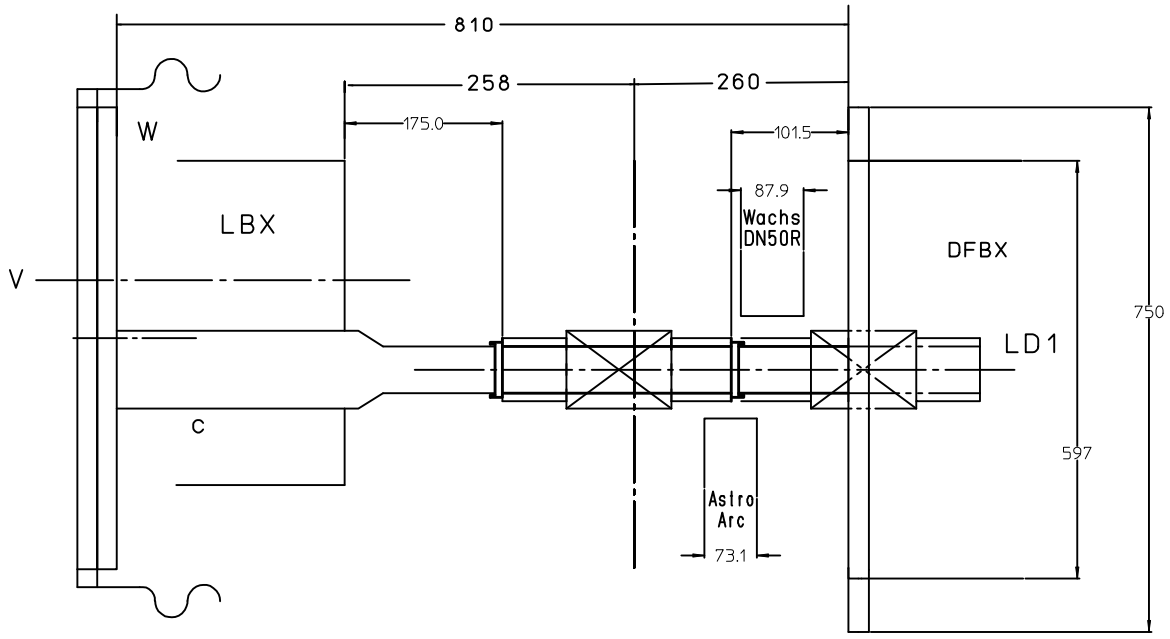


Figure 5.9.4-1. LD1 Interconnection Layout.

5.9.5 THERMAL SHIELD COOLING (EX AND E2) CONNECTIONS

These connections are similar to the LD line interconnection and will be made with bellows listed in Table 5.8-2. The bellows length and longitudinal dimensions are listed in Tables 5.3-1, 5.3-2 and 5.8-2.

5.9.6 BEAM SCREEN COOLING AND 1.9K SUPPLY (CC'2, CC'3, CY2)

These small diameter lines will have expansion loops or flexible hose rather than bellows. The pipes will be welded using a CERN "persistent ring" as used in the QRL [3] and an automatic or hand welder. See Figure 5.9.6-1.

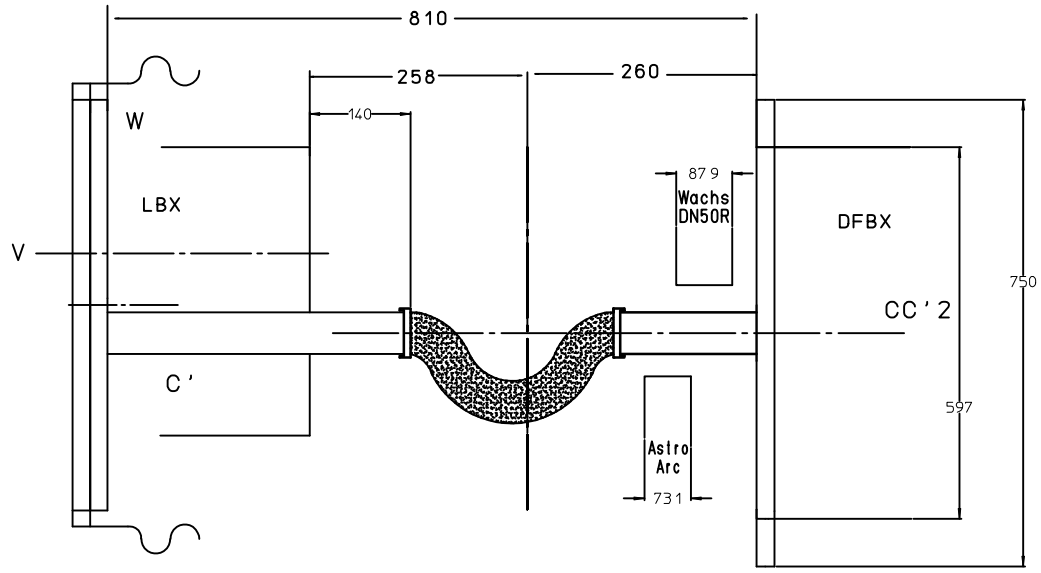


Figure 5.9.6-1. Beam screen cooling and 1.9 K supply layout. (Typical for CC' and Cy lines.)

5.9.7 RADIAL CLEARANCE ENVELOPES FOR WELD CONNECTIONS

CERN has increased the required radial clearance for weld connections from 40 mm to 45 mm. DFBX pipe-welding clearance envelopes for 45 mm are shown in Figure 5.9.7-1 and 5.9.7-2. On the left side, there is adequate clearance for the automatic welder at all pipe connections except the CC'2 and Ex pipes. On the right side, the XB line, as well as CC'2 and Ex, radial clearance envelopes interfere with adjacent pipe diameters. From the figures, there appear to be radial clearance issues for pipes V, MBX1, and MBX2. To alleviate automatic welder clearance issues, the bore tube connection, V, should be made prior to the MBX1 to m/c connection. (The space reserved for the bus interconnect will accommodate the orbital welder.) For each of the other pipes, the location of the weld connection is longitudinally distant from the interfering flange radius and the radial clearance to the adjacent pipe is sufficient for the orbital welder. (Note that pipe interconnects take place at multiple "Y" locations; see Tables 5.3-1 and 5.3-2.) In the case of CC'2 and Ex, and XB on the right side, it may be feasible to temporarily move CC'2 away from the Ex pipe to gain enough clearance for the orbital welder as CC'2 is a small-diameter pipe. Otherwise, a hand weld may be required for these interconnects.

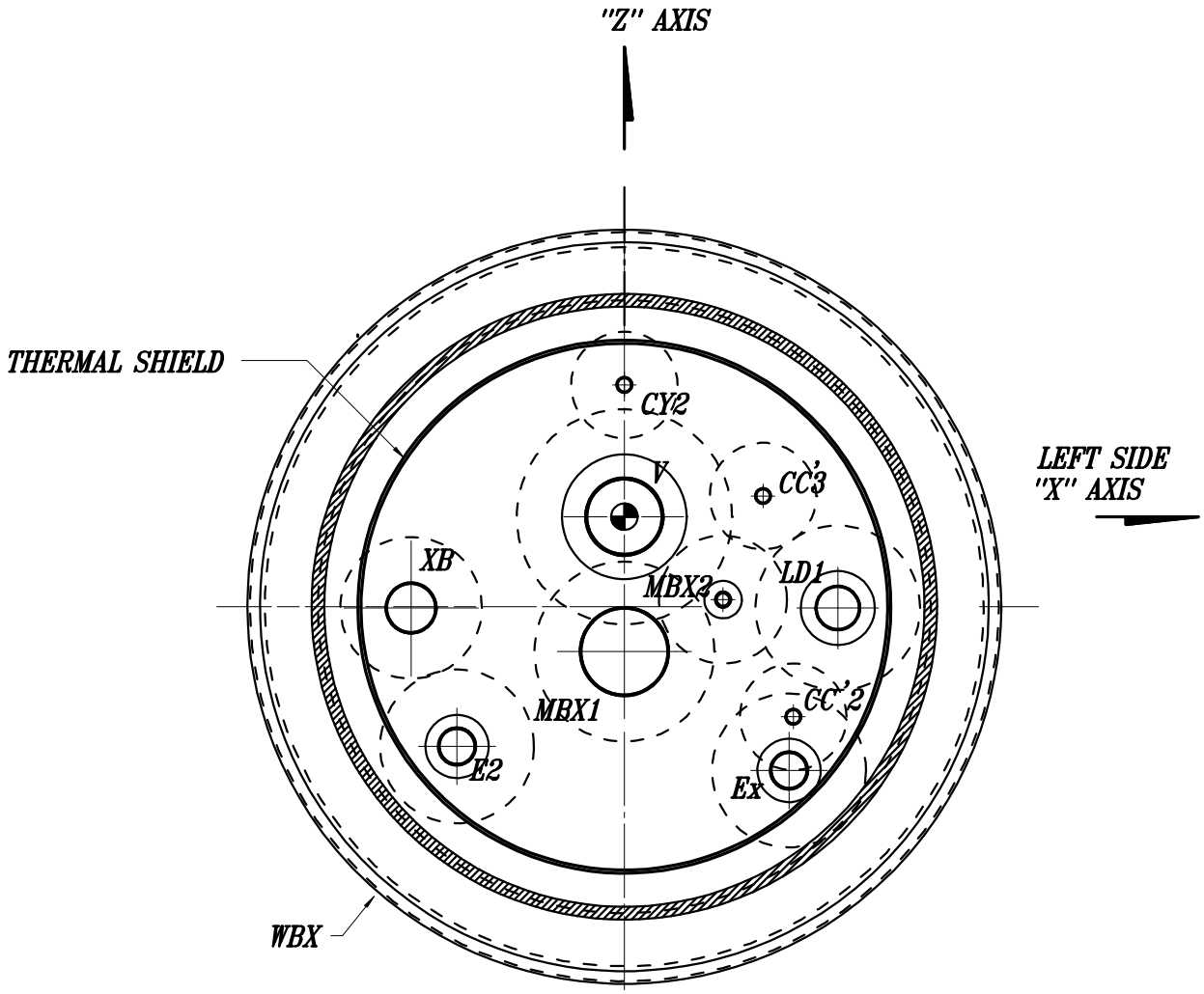


Figure 5.9.7-1. DFBX (left-side) 45-mm automatic orbital welder clearance envelopes shown as dashed lines between flanged pipe ends for piping weld connections at interconnect plane. (Thermal shield does not extend into interconnect region.)

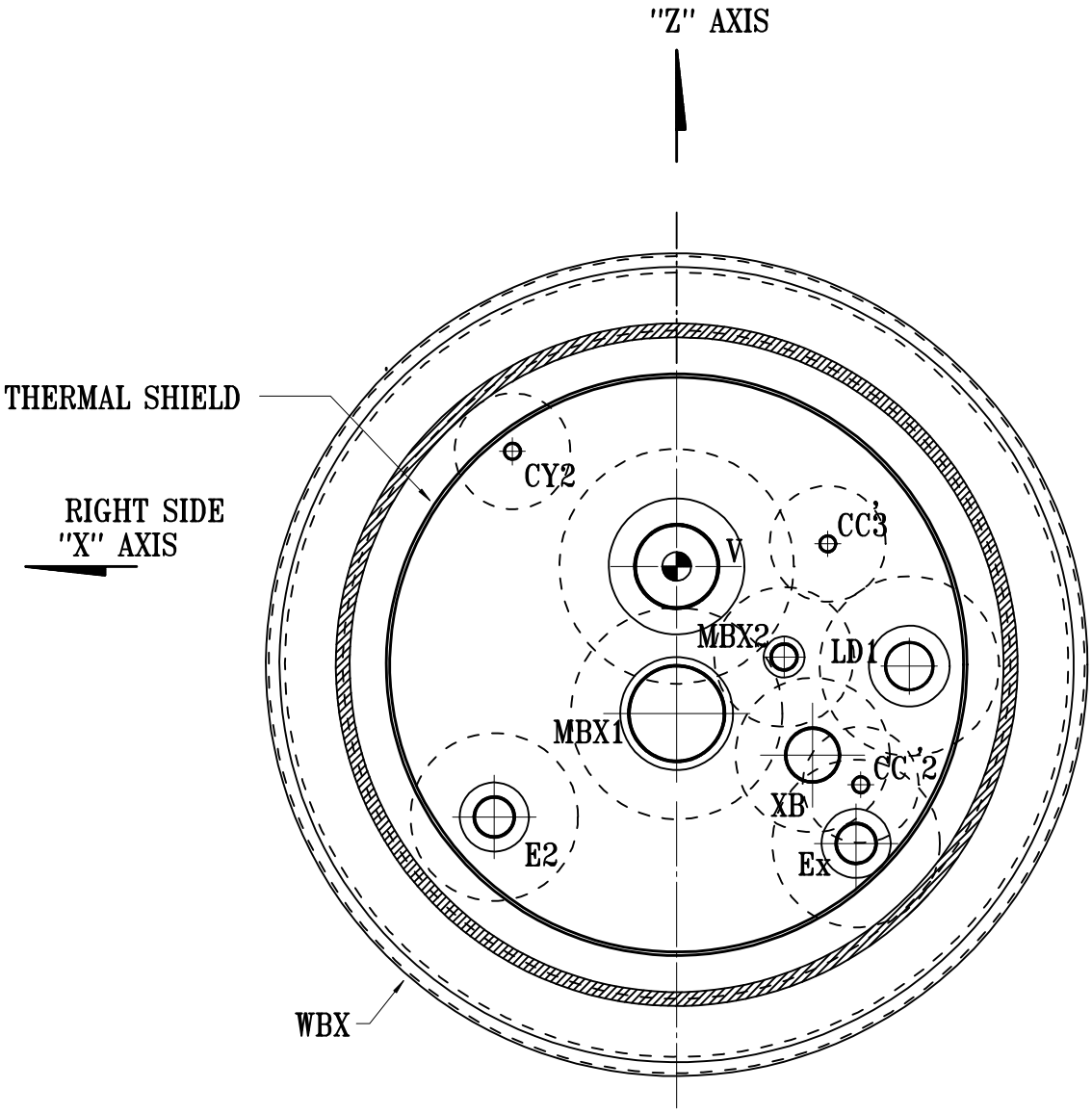


Figure 5.9.7-2. DFBX (right-side) 45-mm automatic orbital welder clearance envelopes shown as dashed lines between flanged pipe ends for piping weld connections at interconnect plane. (Thermal shield does not extend into interconnect region.)

5.10 THERMAL SHIELD BRIDGE CONNECTION DETAILS

The thermal shield bridge will be fabricated in two parts, upper and lower halves, bolted together over the piping in the interconnect region using a clam shell design. The overall length of the shield bridge is about 800 mm. The bridge will be have a mechanical feature on the DFBX end for connection to the thermal shields at the DFBX end and slide over the heat shield at the D1 end.

5.11 VACUUM VESSEL CONNECTION DETAILS

5.11.1 SEALING FLANGE

The sealing flange on the DFBX contains an O-ring; the groove details are shown in Figure 5.11-1. This design is based on the CERN design used elsewhere on the LHC and will, alternately, allow the use of helicoflex metal seals instead of O-rings.

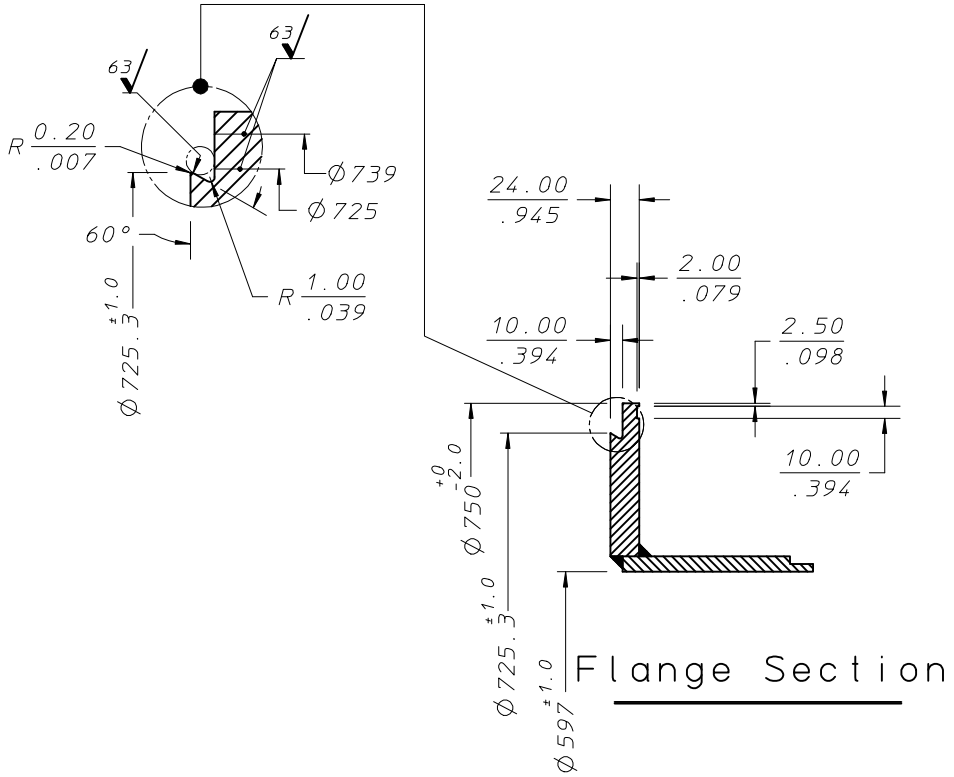


Figure 5.11-1 Sealing Flange O-ring Details.

5.11.2 STRUTS FOR VACUUM LOADING

Since the supports for D1 can sustain an axial vacuum load, external tie bars will not be required to react vacuum loading as they are on the LQX side. The DFBX box will react thrust loads, once installed and positioned, via tie down brackets to the tunnel floor.

6. ELECTRICAL INTERFACES

6.1 MAGNET BUS BARS

The DFBX bus bars that provide powering for the LBX dipole are contained in the duct designated MBX1. The bus parameters are shown in Table 6.1-1. The fixed point for the bus bars on the DFBX side is the midplane of the DFBX LHe chamber. A spider on the DFBX side of the interconnect will provide transverse support for the bus interconnect.

Thermal contraction will be accommodated by a flexible bus section in the LBX, as there is little flexibility in the DFBX bus.

Table 6.1-1 Power Busses in the MQX1 duct.

Item	**Insulated Bus Area (mm x mm)**	**Number of Busses**	**Test Voltage** [6]	**Free Length (m)**
D1 Power Bus (+)	16.5 x 3.6	1	1400	0.5
D1 Power Bus (-)	16.5 x 3.6	1	1400	0.5

A sketch of the bus bar is shown in Figure 6.1-1. In the connection to the MBX bus, the conductors are spread apart and soldered in the interconnection region. Figure 6.1-1 also shows a longitudinal view of the interconnection. The solder joint will be soldered over the full transposition pitch. Strain relief is required at all connections; a bracket will be used to secure a splice block to support the connection.

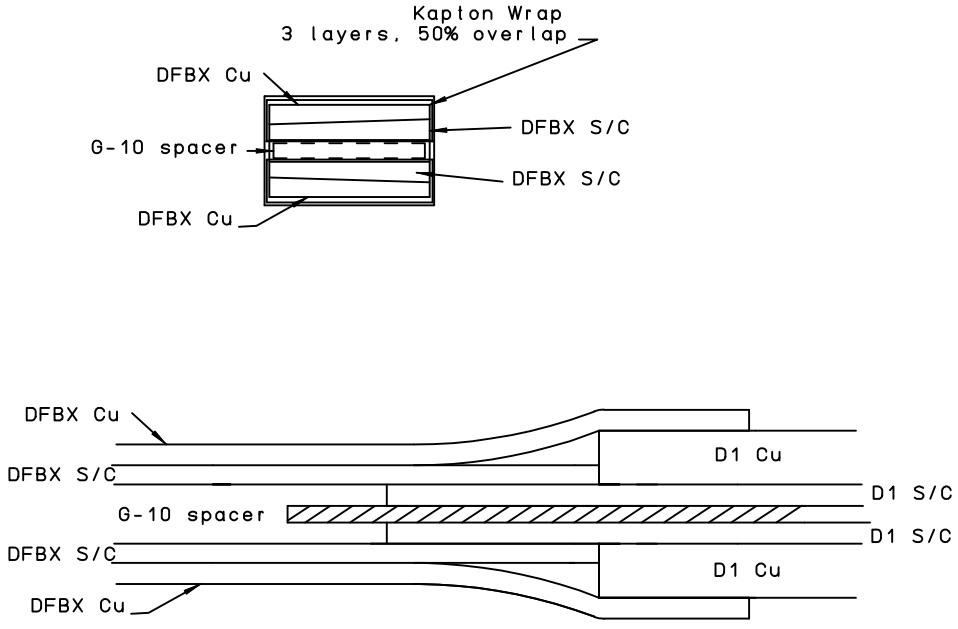


Figure 6.1-1 Cross-sectional view of the DFBX bus bar in the DFBX and longitudinal view of the DFBX bus bar connection to the D1 bus.

6.2 MAGNET DIAGNOSTICS

The magnet diagnostic cables are given in [1] and are listed in Table 6.2-1. The connection will be made in a 25-mm diameter tube (MBX2) on the D1 end volume. The junction area will be sealed with a welded stainless steel tube. All wires are insulated with Kapton. Strain relief is required at all wire connections as specified in LHC-QI-ES-0001 [7].

Table 6.2-1 Magnet Diagnostic Cables

Item	Cable Type	AWG	Number of Cables	Test Voltage [6]	Free Length (m)
Voltage Taps	3-wire	28	2	1400	0.5
Quench Heaters	2-wire	14	2	1200	0.5
Thermometers	4-wire	32	2	200	0.5
Warm up Heaters	2-wire	22	2	200	0.5
Phase separator liquid indicators (temp. sensors)	4-wire	26	2	TBD	0.5

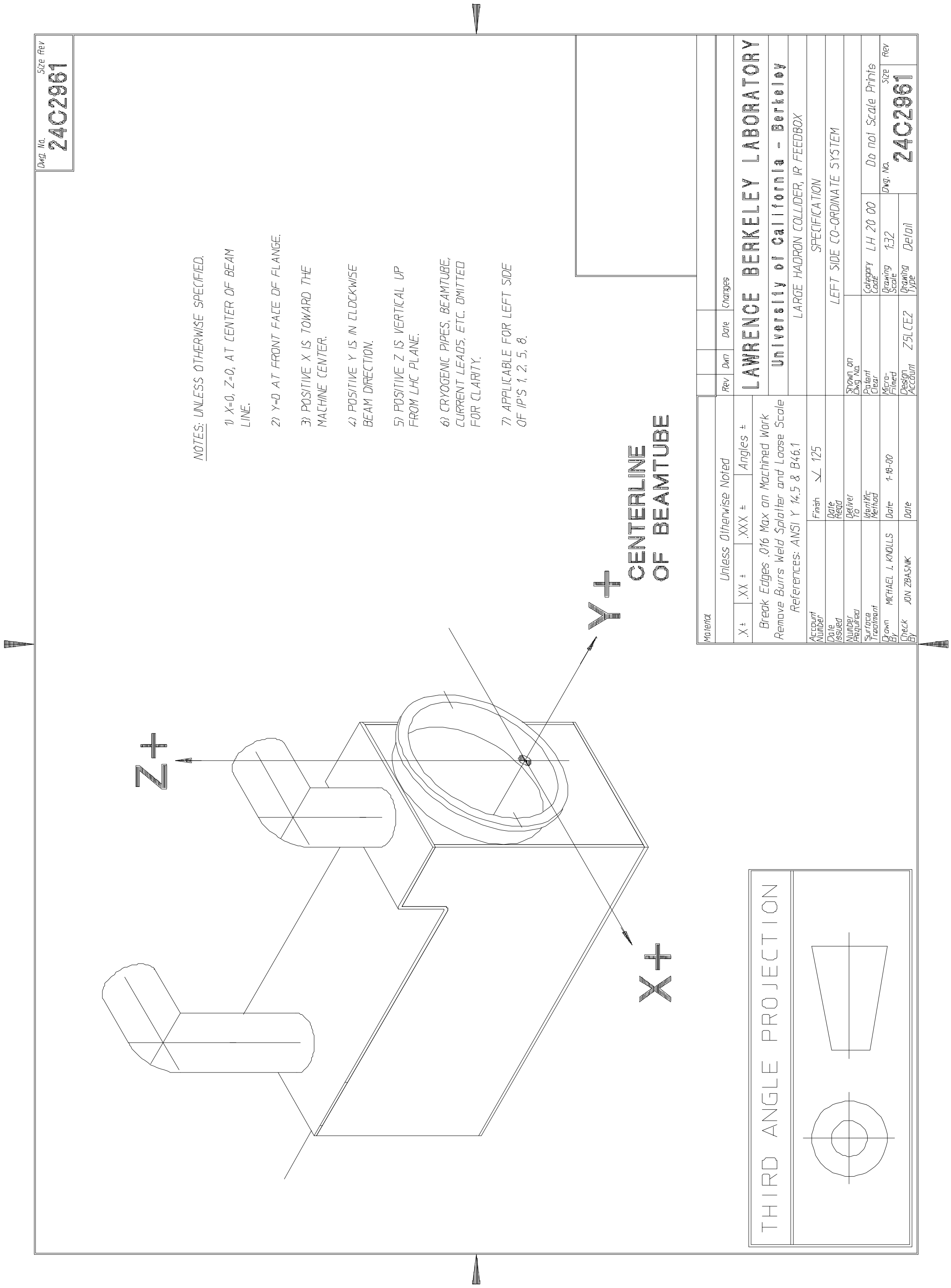
7. DRAWINGS

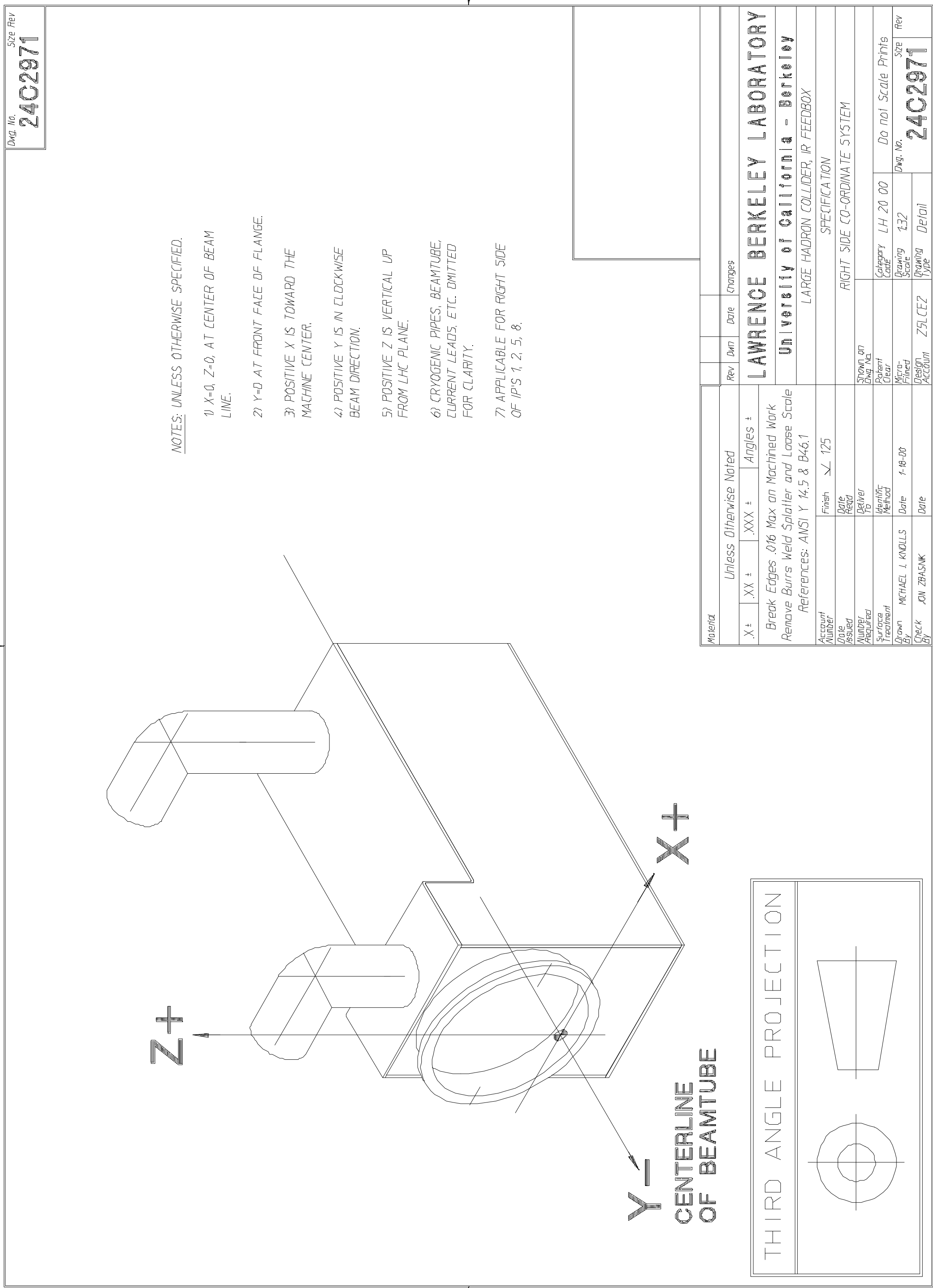
a. LHCLQXI_0010, Shield Line Bellows Assembly, FNAL 5520-MD-390056.
b. LHCLQXI_0007, Shield Line End Flange, FNAL 5520-MB-390035.
c. LHCLQXI_0001, LHC IRQ Cryostat Cold Down Bellows, FNAL 5520-MC-390061.
d. LHCLQXI_0006, Cool Down Line End Flange, FNAL 5520-MB-390033.
e. LHCLBX__0003, RHIC Interconnect Bellows, BNL 01055055.
f. LHCMBX__0003, BNL flange m/c line, BNL 12130089.
g. LHCMBX__0004, BNL flange i line, BNL 14010306.
h. LHCLSX__0003D, LHC Layout Drawings of Long Straight Sections, IR 2 Left
i. LHCLSX__0004D, LHC Layout Drawings of Long Straight Sections, IR 2 Right.
j. LHCLSX__0015D, LHC Layout Drawings of Long Straight Sections, IR 8 Left.
k. LHCLSX__0016D, LHC Layout Drawings of Long Straight Sections, IR 8 Right.
l. LHCDFBX_0001, Distributive Feedbox Schematic,.
m. LHCDFBX_0010, Connections to D1 at IR2 left and IR8 Left.
n. LHCDFBX_0011, Connections to D1 at IR2 right and IR8 Right.
o. LHCLBX__XXXX, Bellows, 2.00 DIA, BNL 14130002A.

8. REFERENCES

1. LHC Interface Specification, "MBX Dipoles – D1," LHC-MBX-ES-0002.00.
2. LHC Interface Specification, "Inner Triplet Feedboxes: DFBX – Beam Tube," LHC-DFBX_-ES-0220.00.
3. LHC Interface Specification, "Inner Triplet Feedboxes General Interfaces," LHC-DFBX_-ES-0200.00.
4. LHC Interface Specification, "Inner Triplet Feedboxes: DFBX to LQXB," LHC-DFBX-ES-0210.00.
5. LHC Engineering Specification, " D1-Dipole Cooling Scheme," LHX-MBX-ES-0001.00.
6. LHC Engineering Specification, "Voltage Withstand Levels for Electrical Insulation Tests on Components and Bus Bar Cross Sections for the Different LHC Machine Circuits," LHC-PM_-ES-0001 rev 1.1, 31 August 2000.
7. LHC Engineering Specification, "Instrumentation Wires, Connection Techniques and Feedthroughs for the Main Arc LHC Cryomagnets and the QRL," LHC-QI-ES-0001 rev 2.0, 27 September 2000.

9. APPENDIX A – DEFINITION OF DFBX LOCAL COORDINATES


Dwg. No. 24C2961 Size Rev
NOTES: UNLESS OTHERWISE SPECIFIED.
1) X=0, Z=0, AT CENTER OF BEAM LINE.
2) Y=0 AT FRONT FACE OF FLANGE.
3) POSITIVE X IS TOWARD THE MACHINE CENTER.
4) POSITIVE Y IS IN CLOCKWISE BEAM DIRECTION.
5) POSITIVE Z IS VERTICAL UP FROM LHC PLANE.
6) CRYOGENIC PIPES, BEAMTUBE, CURRENT LEADS, ETC. OMITTED FOR CLARITY.
7) APPLICABLE FOR LEFT SIDE OF IP'S 1, 2, 5, 8.
CENTERLINE OF BEAMTUBE
Y+
Z+
X+
THIRD ANGLE PROJECTION
Material
Unless Otherwise Noted
.X ± .XX ± .XXX ± Angles ±
Break Edges .016 Max on Machined Work
Remove Burrs Weld Splatter and Loose Scale
References: ANSI Y 14.5 & B46.1
Finish 125
Account Number
Date Issued
Date Reqd
Number Required
Deliver To
Surface Treatment
Identific Method
Drawn By MICHAEL L. KNOLLS Date 4-18-00
Check By JON ZBASNIK Date
Rev Dwn Date Changes
LAWRENCE BERKELEY LABORATORY
University of California - Berkeley
LARGE HADRON COLLIDER, IR FEEDBOX
SPECIFICATION
LEFT SIDE CO-ORDINATE SYSTEM
Shown on Dwg No.
Patent Clear
Category Code LH 20 00
Micro-Filmed
Drawing Scale 1:32
Do not Scale Prints
Design Account Z5LCE2
Drawing Type Detail
Dwg. No. 24C2961 Size Rev


Dwg. No. 24C2971 Size Rev
NOTES: UNLESS OTHERWISE SPECIFIED.
1) X=0, Z=0, AT CENTER OF BEAM LINE.
2) Y=0 AT FRONT FACE OF FLANGE.
3) POSITIVE X IS TOWARD THE MACHINE CENTER.
4) POSITIVE Y IS IN CLOCKWISE BEAM DIRECTION.
5) POSITIVE Z IS VERTICAL UP FROM LHC PLANE.
6) CRYOGENIC PIPES, BEAMTUBE, CURRENT LEADS, ETC. OMITTED FOR CLARITY.
7) APPLICABLE FOR RIGHT SIDE OF IP'S 1, 2, 5, 8.
Z+
X+
Y−
CENTERLINE OF BEAMTUBE
THIRD ANGLE PROJECTION
Material
Unless Otherwise Noted
.X ± .XX ± .XXX ± Angles ±
Break Edges .016 Max on Machined Work
Remove Burrs Weld Splatter and Loose Scale
References: ANSI Y 14.5 & B46.1
Account Number
Date Issued
Number Required
Surface Treatment
Finish 125
Date Reqd
Deliver To
Identific Method
Drawn By MICHAEL L. KNOLLS Date 1-18-00
Check By JON ZBASNIK Date
Rev Dwn Date Changes
LAWRENCE BERKELEY LABORATORY
University of California - Berkeley
LARGE HADRON COLLIDER, IR FEEDBOX
SPECIFICATION
RIGHT SIDE CO-ORDINATE SYSTEM
Shown on Dwg. No.
Patent Clear
Micro-Filmed
Design Account Z5LCE2
Category Code LH 20 00
Drawing Scale 1:32
Drawing Type Detail
Do not Scale Prints
Dwg. No. 24C2971 Size Rev